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Developmental trajectories of cigarette use from early adolescence into young adulthood

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Abstract

This study identified developmental trajectories of cigarette smoking from early adolescence into young adulthood, and delineated whether risk factors derived from a social learning-problem behavior framework could differentiate among trajectories. Participants ($N = 374$) were interviewed five times from age 12 until age 30/31. Using growth mixture modeling, three trajectory groups were identified — heavy/regular, occasional/maturing out, and non/experimental smokers. Being a female, having higher disinhibition, receiving lower grades, and more frequent use of alcohol or drugs significantly increased the probability of belonging to a smoking trajectory group compared with being a nonsmoker. Higher disinhibition and receiving lower grades also differentiated regular smokers from the rest of the sample. None of the risk factors distinguished occasional from regular smokers. When models were tested separately by sex, disinhibition, other drug use, and school grades were associated with smoking for both sexes. On the other hand, environmental factors, including socioeconomic status, parent smoking and friend smoking, were related to smoking for females but not for males. Sex differences in developmental trajectories and in smoking behavior among regular smokers were notable. Future research should examine transitions and turning points from adolescence to adulthood that may affect cessation and escalation differently for males and females.

Keywords: Cigarette smoking; Tobacco use; Trajectories; Risk factors; Transitions; Sex differences

1. Introduction

Despite decreasing numbers of cigarette smokers since the late 1970s, cigarette use remains a serious public health problem (Johnston et al., 2000a; SAMSHA, 1996; Shadel et al., 2000). Youths aged 12–17 years compared with all other age groups have the greatest likelihood of beginning daily smoking (Giovino, 1999; SAMSHA, 1996). Recently, there has been a slight decrease in smoking among high school students, yet in 1999 over one third were current smokers (smoked in the last 30 days) by the time they graduated (Johnston et al., 2000a). In addition, smoking by college students has increased significantly during the 1990s (Johnston et al., 2000b; Wechsler et al., 1998). These increases are especially alarming given that adolescence is a key developmental period for the emergence of life long patterns of cigarette use (Choi et al., 1997; Colby et al., 2000; Eissenberg and Balster, 2000; Kessler, 1995).

It is, therefore, important to understand the development of smoking behavior during this critical age period (Shadel et al., 2000). Researchers have identified several stages in the development of smoking behavior from initiation to addicted smoking (Flay et al., 1983; Leventhal and Cleary, 1980; Mayhew et al., 2000; McNeill, 1991). Although the initiation/experimentation stage has been characterized extensively, less is known about the nature of transitions between stages (Croft et al., 1985; Fergusson and Horwood, 1995; Mayhew et al., 2000). One third to one-half of those who try cigarettes become regular (Kessler, 1995) or dependent smokers (Shiffman, 1991). Further, nearly 90% of those who smoke regularly eventually become addicted to nicotine (Lindsay and Rainey, 1997). In spite of the

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addictive potential of cigarettes, some individuals seem to maintain long-term cigarette smoking without becoming dependent (Shiffman, 1991; Shiffman et al., 1990). Yet, little is known about occasional smokers and what protects them from becoming dependent on cigarettes. Thus, we need to understand more about the stages and transitions between stages of cigarette smoking, as well as individual differences in vulnerability to the transition to regular smoking (Choi et al., 1997; Croft et al., 1985; Chassin et al., 1986; Hajeck et al., 1995; Hirschman et al., 1984; Mayhew et al., 2000; Shiffman, 1991).

In earlier research, stages of smoking have been arbitrarily defined by the researchers rather than empirically determined (Mayhew et al., 2000). This practice has led to inconsistent findings regarding patterns of smoking and predictors. Terms such as initiator, experimenter, adopter, experimental nonadopter, regular smoker, established smoker, current smoker, former smoker, and dependent smoker have been used across studies without consistency in meaning. For example, regular smoking has been defined by frequency, ranging from daily (Covey and Tam, 1990) to three times per week (Patton et al., 1996) to weekly (Breslau et al., 1991; Chassin et al., 1996) to once in the last month (Biglan et al., 1995). In other studies, it has been defined by quantity, for example, smoking at least one-half pack daily (Shiffman et al., 1994; Winefield et al., 1992) or smoking 100 cigarettes lifetime (Choi et al., 1997). Further, most studies of cigarette smoking have employed limited predictors resulting in restricted analyses that fail to control for competing predictors.

In addition, earlier research on cigarette smoking has been limited by its focus on variable-centered approaches. Such approaches do not take into account possible heterogeneities in the developmental paths of smoking behavior (Mayhew et al., 2000). A variable-centered approach produces models that describe the average behavior of the sample, but not necessarily the behavior of those individuals showing the greatest deviation from the mean (Hill et al., 2000). It is these more extreme groups (e.g. those adolescents who smoke heavily throughout adolescence and adulthood), who may be most interesting to study and most informative for prevention and intervention planning. There is growing recognition that greater attention should be directed towards individual growth curves and the description and explanation of intrainidivual change (Mayhew et al., 2000; White et al., 1998). Thus, the first aim of this paper was to empirically identify and characterize different developmental trajectories of cigarette smoking from early adolescence into young adulthood.

The second aim of this paper was to identify the risk factors that differentiate among these various developmental trajectories. Two prominent theories have been used to explain the development of adolescent substance use — social learning theory and problem behavior theory. In this study, both are combined to provide a more thorough assessment of the risk factors associated with developmental trajectories of cigarette use. Social learning variables were selected based on Akers (1985) approach to social learning theory. Akers's theory combines Bandura (1977) social learning theory with Sutherland (1947) differential association theory. According to Akers (1985), social learning is a process whereby differential associations provide the environment in which exposure to definitions, imitation of models, reinforcement and punishment takes place. The definitions, in interaction with models and anticipated reinforcers, produce initial deviant behavior such as drug use. After initial use, imitation becomes less important while definitions and behavioral consequences of use become more important (White and Bates, 1995; White et al., 1990).

Problem behavior theory argues that deviant behaviors (e.g. drug use, aggression, delinquency and precocious sexual behavior) cluster together during adolescence and that this cluster of behaviors is negatively related to conventional behavior (Jessor and Jessor, 1977). Jessor and his colleagues (Jessor and Jessor, 1977; Jessor et al., 1991) have demonstrated that problem behaviors can be explained by the same set of environmental and personality variables. Overall, support for the concept of a single problem behavior syndrome has been mixed (White and Labouvie, 1994; Donovan, 1996). Yet, it is important to consider cigarette smoking in relation to other problem and conventional behaviors and, thus, these behaviors were included in the model.

Although few studies have applied either social learning or problem behavior frameworks to study the development of cigarette smoking (for exceptions Akers and Lee, 1996; Chassin et al., 1984; Flay et al., 1994), several studies have provided support for their various theoretical components. Numerous studies have demonstrated the importance of differential associations, that is parents, friends, and siblings for smoking, although their relative importance varies by age and stage of smoking (Flay et al., 1983, 1998; Hirschman et al., 1984; Chassin et al., 1984, 1986; Bailey et al., 1993; Croft et al., 1985; Melby et al., 1993; Patton et al., 1996; Biglan et al., 1995). Others have shown the salience of definitions (e.g., positive attitudes about use) (Chassin et al., 1984, 1990; Croft et al., 1985; Hirschman et al., 1984; Rose et al., 1996b). Further, psychological reinforcement from smoking appears to maintain smoking behavior (Rose et al., 1996b; Wetter et al., 1994); those individuals with negative affect or with certain personality traits may be more likely to derive positive and negative reinforcement from smoking (Shadel et al., 2000). For example, higher levels of depression and lower levels of self-esteem have been

found to predict smoking behavior (Glassman et al., 1990; Kandel and Davies, 1986; Newcomb et al., 1989; Patton et al., 1996), although the findings have been inconsistent across studies (Breslau et al., 1991; Winefield et al., 1992). As well, higher levels of risk taking and sensation seeking have been related to smoking behavior (Hirschman et al., 1984; Zuckerman, 1991).

Smoking behavior has been strongly associated with other problem behaviors, especially heavy drinking and illicit drug use (Breslau et al., 1991; Flay et al., 1998; Kozlowski et al., 1993; Lewinsohn et al., 2000; Patton et al., 1996; Sher et al., 1996; Shiffman and Balabanis, 1996), as well as delinquency (Breslau et al., 1993; Chassin et al., 1986; Diem et al., 1994). In addition, smoking has been negatively related to conventional behaviors, such as academic achievement (Chassin et al., 1984, 1996; Diem et al., 1994; Mayhew et al., 2000; Newcomb et al., 1989; Rose et al., 1996a).

This study extended earlier research on transitions in cigarette use in several ways. First, prospective data were collected from a nonclinical sample of males and females over a large age span from early adolescence into adulthood. Second, a person-centered approach was used to identify developmental trajectories of cigarette smoking from early adolescence into young adulthood. Third, the associations of putative risk factors and trajectory group membership were examined within a theoretical model which took into account concepts from both social learning and problem behavior theories. Finally, risk factors from multiple domains encompassing the individual, the family, and the environment were included in the model.

2. Method

2.1. Study population

Eligible adolescents were originally recruited through a random telephone sampling of New Jersey. The procedure used was designed to take into account unlisted numbers and differences in population densities associated with different telephone interchanges. The procedure was estimated to reach 95% of all households in the specified geographic area (i.e. more than 95% of NJ household had telephones at that time). Between 1979 and 1981, successive rounds of telephone calls filled quotas of 200–225 males and females aged 12, 15, or 18. Following the anonymous telephone survey, eligible participants were visited in their homes and then came to the test site for a day of data collection. Participants were comparable to those who refused on demographic characteristics and selected behaviors assessed during the initial telephone interview, except that participants displayed slightly higher levels of parental income and education. (Only 5% of all calls, including no answers, business phones, and refusals, resulted in no response.) The sample was similar to the population of New Jersey at that time in terms of family income and religion (Bureau of the Census, 1981). Overall, the sample is most representative of white, working- and middle-class youth living in a metropolitan area of the Eastern United States. (For more detail on recruitment, sample, and design, see Pandina et al., 1984.) Patterns of drug use in this sample were comparable to those reported in national representative samples for same age peers living in the Northeast region of the US at that time (Johnston et al., 2000a,b; SAMSHA, 1996).

The participants for this study were interviewed initially between 1979 and 1981 (Time 1, T1) at the age of 12 ($N = 447$). They returned 3 years later in 1982–1984 (Time 2, T2), again in 1985–1987 (Time 3, T3), again in 1992–1994 (Time 4, T4), and finally in 1997–1999 (Time 5, T5) at the age of 30/31. A total of 374 participants were retested at T5. A comparison of those who dropped out and those who were tested all five times indicates no significant differences in cigarette use at T1. Out of 15 possible risk factors, only one for males (self-esteem) and one for females (cigarette attitudes) differed significantly (by t-test; $P < 0.003$ and 0.02, respectively) between the follow up and dropout samples. Thus, attrition was deemed to be a minimal problem in this study.

2.2. Measures

2.2.1. Cigarette use

The data were generated from self reports from interviewer-administered questionnaires. Self reports of smoking have been shown to be accurate in most studies, especially when interviewer-administered (Patrick et al., 1994; Rose et al., 1996a). Given that both the dependent and independent measures were assessed with self-reports, there is a potential influence of shared method variance. Nevertheless, this tradition of using self-reports is fairly common in studies of substance use (e.g. Kandel and Davies, 1986; Newcomb et al. 1989).

Data were collected on frequency of smoking in the past year (8-point scale from never to daily) and typical quantity per day (8-point scale from none to more than two packs). A quantity–frequency measure was derived by multiplying typical quantity by frequency. Repeated measures of the log (plus 1) of this quantity–frequency measure at each of the five test occasions were used to develop the smoking trajectory groups. For the descriptive analyses, frequency was recoded to the number of smoking days in the past year and quantity was recoded to the number of cigarettes per day. Data were also collected on age of onset (i.e. the first time a participant tried a cigarette) (Labouvie et al., 1997).

2.2.2. Risk factors

Variables that have been identified as risk factors for initiation, as well as the transition to more intensive use patterns, were selected for inclusion in the model (for a review see Mayhew et al., 2000). The domains of interest included demographic characteristics, differential association variables, definitions, differential reinforcement as operationalized by intrapersonal characteristics that could potentially benefit from nicotine reinforcement, and other problem/conventional behaviors. All risk factors except disinhibition (see below) were measured at T1 in order to increase the likelihood of measuring risk factors prior to initiation and regular smoking, although for some participants who began smoking before T1 this was not possible (i.e. 15% of the sample had tried a cigarette by T1, although only 3.6% had smoked more than twice in the last year at T1). The trajectories are based on patterns of use over time and cigarette use at each of the five test occasions contributes equally to the identification of trajectories. Consequently, these trajectories are based on use intensities that are maintained across extended time intervals. In each case, a large portion of the extended time interval temporally follows when the T1 risk factors were measured. Nevertheless, because risk factors may vary in their temporal stability, caution should be used in inferring a causal nature of association when employing any such modeling technique (Pandina, 1998).

Demographic characteristics included sex and socioeconomic status (highest level of parental education). (Race was not included because the sample was 92% white.) Parents' (i.e. neither parent smoked in past year = 0 versus at least one parent smoked in past year = 1), siblings' (i.e. no siblings smoked in past year = 0 versus any sibling smoked in past year = 1), and close friends' (the proportion from none to all who smoked) cigarette use were assessed. In addition, a variable indicating whether (coded 1) or not (coded 0) a participant's mother smoked while she was pregnant with the participant (as reported by the mother in the home interview) was included. Participants indicated their perception of the number (from none to all) of individuals their own age (i.e. peers) who smoked. Negative beliefs about smoking were measured as the sum of five possible statements to which participants agreed regarding cigarettes (e.g. 'it is harmful to the body', 'people become dependent upon it'). A higher score indicates greater perception of harm potential.

Intrapersonal risk factors included: self esteem (four items describing oneself, e.g. 'being a good person' and 'being smart') and self derogation (four items describing oneself, e.g. 'being mean' and 'being dishonest') from the Rosenberg Self Esteem Scale (Rosenberg, 1965); the depression subscale from the SCL-90R (13 items assessing how often in the last month respondents experienced symptoms of depression such as 'feeling blue' or 'feeling no interest in things') (Derogatis, 1977); and the disinhibition subscale from the Zuckerman Sensation Seeking Scale (eight items such as 'a person should have considerable sexual experience before marriage', 'I like 'wild' uninhibited parties') (Zuckerman, 1979). All of these scales have been validated in earlier studies. Disinhibition was measured at T2 (age 15) due to lack of demonstrated reliability prior to age 14 (Zuckerman, 1979). Adolescent problem/conventional behaviors included educational attachment (four items, e.g. 'school can make a difference in my life') and school performance (grade point average ranging from $A = 1$ to $F = 8$), self-reported drug use (the maximum frequency for alcohol, marijuana, and other drugs in the last year), and delinquency (the sum of the frequency of engaging in nine delinquent behaviors).

2.3. Analysis

A growth mixture model approach was used to develop trajectories of cigarette use. This mixture model method is a semi-parametric group-based technique that allows for cross-group differences in the shape of developmental trajectories (Muthén and Shedden, 1999; Roeder et al., 1999). It is assumed that the population is composed of a mixture of distinct groups defined by their developmental trajectories. This method is especially suited for identifying heterogeneity in types of developmental trajectories rather than assuming them (Nagin and Tremblay, 1999). It allows for identification of population heterogeneity in the level of a behavior at a given time, as well as in the development of the behavior over time. This modeling approach is available through a customized SAS macro (know as Proc Traj) developed by Jones et al., 2001. For greater details on the advantages and disadvantages of this modeling technique see Hill et al. (2000) and Roeder et al. (1999).

Proc Traj provides three different distribution options for modeling the data: categorical (for nominal or dichotomous data), zero inflated Poisson (used primarily for count data, such as number of convictions), and censored normal. Given the high number of nonsmokers and the distribution of quantity–frequency scores across smokers, the censored normal distribution option was chosen because it best reflected the distribution of cigarette smoking in this sample (White et al., 2001). After exploratory analyses, a quadratic rather than a linear growth model was selected because of the improvement in data fit (Chassin et al., 1996). An important step in the analysis is to determine the optimal number of groups that best describes the data. This is accomplished by repeating the analyses and adding an additional group each time. Although there is no definitive statistic for determining the optimal number of groups, most experts suggest that the Bayes Informa-

tion Criterion (BIC) should be used to determine the optimal number of trajectory groups when testing mixture models (D'Unger et al., 1998; Keribin, 2000). The model with the smallest absolute BIC is chosen. The BIC criterion rewards parsimony and so tends to favor fewer groups, but it is known to be reliable (Keribin, 2000).

After determining the number of groups, the next step is to calculate the probability of membership on the part of each participant in the various groups that comprise the model. Earlier applications of the growth mixture modeling approach assigned each individual to the class for which he or she had the highest probability of belonging (e.g. Nagin et al., 1995). This approach was used for the descriptive analyses only. For the regression analyses, the probabilities of selected group membership were used as the dependent variables. That is, probability of membership in each group for each individual was assigned and these probabilities were used as weights in the analyses. This technique reduces bias and measurement error, especially for individuals whose observed behavior does not clearly match any one group's trajectory (Nagin and Tremblay, 1999; Roeder et al., 1999). An examination of the distribution of probability scores for the groups indicates that the vast majority of subjects were located towards the extremes rather than towards the middle[1]. Nevertheless, because the regression analyses use the probabilities as the dependent variables, the analyses give greater weight to those individuals with the higher probabilities for a particular group. In other words, the differences between those subjects at the extremes and those in the middle are corrected by the weighting procedure.

Once the trajectory group probabilities were identified, descriptive (chi square (χ^2), t-tests and analyses of variance (ANOVA) and multiple regression analyses were conducted using SAS (SAS, 1990). For the multiple regression analyses, none of the correlations among the risk factors were above 40 thus, multicollinearity was deemed not to be a problem[2].

3. Results

3.1. Descriptive statistics

By age 30/31, 76.8% of the females and 70.6% of the males had ever tried a cigarette, which is comparable to national studies of participants in their age range (SAMSHA, 1996). Further, 38.4% of the females and 32.1% of the males had become daily smokers at one test occasion at least. Of those who had tried a cigarette, 50.0% of the females and 45.4% of the males became daily smokers at some point. None of these sex differences were statistically significant ($P > 0.05$) as evaluated by χ^2-analyses.

Females (mean age of first ever trying a cigarette = 12.7) began smoking earlier than males (mean age = 13.4), however, based on a t-test this difference was not statistically significant ($t = -1.52$, $P = 0.13$). Females also began smoking daily earlier than males (mean age 15.7 vs. 17.4), and this difference was statistically significant ($t = -3.2$, $P < 0.002$).

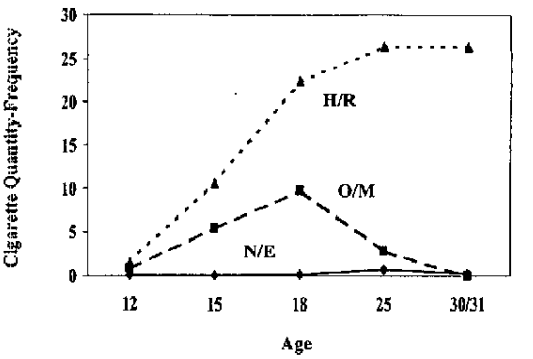

Fig. 1. Observed cigarette quantity–frequency scores at each age for each trajectory group; notes: N/E, non/experimental smokers; O/M, occasional/maturing out smokers; H/R, heavy/regular smokers. Quantity–frequency scores are the product of frequency last year times quantity on a typical day.

3.2. Trajectories of cigarette use

A two-group (BIC = −2530), three-group (BIC = −2195), and four-group (BIC = −2554) model was tested. Based on the BIC criterion, a three-group model was selected as the best fitting model. Fig. 1 presents the observed trajectories for each of three trajectory groups. The trajectory groups were labeled: non/experimental smokers (39.6%), occasional/maturing out smokers (19.0%), and heavy/regular smokers (41.4%). Table 1 shows the sex differences in trajectory group

Table 1
Sex differences in trajectory group membership

	Non-smokers	Occasional smokers	Heavy smokers
Females	43.2	70.4	49.0
Males	56.8	29.6	51.0
Total	39.6	19.0	41.4
($N = 374$)	($N = 148$)	($N = 71$)	($N = 155$)

[1] The distribution of probabilities for each group is presented in Table 1, which is available on the journal home page- http://www.elsevier.com/locate/drugalcdepsuppmat

[2] The correlation matrix is presented in Table 2, which is available on the journal home page- http://www.elsevier.com/locate/drugalcdepsuppmat

Table 2
Trajectory group difference in frequency and quantity of cigarette use at each occasion by sex

	Nonsmokers		Occasional smokers		Heavy smokers	
	Females	Males	Females	Males	Females	Males
Number of days						
Last year						
T1[a]	0.02	−0.00	1.47	6.50	15.29	5.22
T2[a,b,c]	0.05	0.04	40.62	49.86	150.29	50.16
T3[a,c]	0.94	0.04	66.05	91.31	268.86	170.46
T4[a]	0.23	5.33	18.46	6.69	261.41	221.48
T5[a]	0.02	4.43	−0.00	−0.00	254.11	223.85
Average number of cigarettes						
Per day						
T1[a]	0.02	0.07	0.41	0.30	0.79	0.47
T2[a,c]	0.10	0.08	1.73	2.33	6.51	3.28
T3[a,c]	0.20	0.10	3.65	5.07	12.03	8.73
T4[a]	0.09	0.60	1.58	2.50	13.65	13.90
T5[a]	0.11	0.27	−0.00	−0.00	14.33	14.68

Note T1 age = 12; T2 age = 15; T3 age = 18; T4 age = 25; T5 age = 30/31.
[a] Significant group effect.
[b] Significant sex effect.
[c] Significant group by sex effect.

membership. There were significantly more females than males in the occasional group ($\chi^2 = 14.51$, df = 2, $P = 0.001$).

Three (trajectory group) by two (sex) analysis of variance were conducted for frequency (number of days smoked in the last year) and quantity (number of cigarettes smoked per day). The group means for these measures at each test occasion are shown separately for females and males in Table 2. Pos hoc comparisons indicate that there were significant group differences in frequency and quantity of smoking at every test occasion[3]. At T1, only the heavy smokers differed significantly from the nonsmokers and at T5, the heavy smokers differed significantly from the other two groups. At the other three test occasions, all three groups differed significantly from each other. These data support the validity of the three trajectory groups. The occasional/maturing out group stands out at T5 (age 30/31) when the mean is zero for quantity and frequency of smoking. Also at T4 (age 25), the male nonsmokers smoked an average of 5 days in the last year, but smoked on average less than one cigarette per day. Although heavy smokers (mean age 12.3) began smoking earlier than occasional smokers (mean age 12.9), this difference was not statistically significant ($t = 1.54$, $P < 0.12$).

Males and females did not differ significantly in their frequency or quantity of smoking at any age except age 15 (T2), when females smoked significantly more often. There were significant age by group differences at ages 15 and 18. At these ages, females in the heavy smoking group smoked more often and more cigarettes than males in the heavy smoking group, but females and males did not differ in quantity nor frequency in the other two groups. Thus, it appears that females begin to smoke earlier than males and female smokers smoke at higher rates during adolescence. However, by age 21 males catch up to females.

3.3. Risk factor differences among smoking trajectories

Table 3 presents results from the regression analyses. The first column of Table 3 presents the standardized beta weights for belonging to either the occasional or regular smoking groups versus the nonsmoker group. In other word, this model tests the risk factors associated with becoming a smoker versus not becoming a smoker. Being a female, having higher disinhibition, receiving lower grades, and using alcohol or drugs more frequently significantly increased the probability of belonging to a smoking trajectory group compared with being a nonsmoker.

The second column of Table 3 presents the standardized beta weights for belonging to the regular smoker group versus the nonsmoker and occasional smoker groups. Thus, this model tests what variables differentiate heavy smokers from all other participants. Higher disinhibition and lower grades in early adolescence were associated with heavy smoking over the life course.

The last column of Table 3 presents the results of a model testing the probability of belonging to the regu-

[3] The *F*-test statistics are presented in Table 3, which is available on the journal home page- http://www.elsevier.com/locate/drugalcdepsuppmat

lar smoking group versus the occasional group. This model examines the probability of becoming a heavy smoker if you ever become a smoker. This model did not achieve statistical significance ($P = 0.07$).

Sex differences in the risk factors for smoking trajectories were also examined. Due to smaller Ns when participants were divided by sex, the model was split into two to meet power requirements. The first model tested the environmental factors (significant others' smoking) and the second included the individual factors (attitudes, personality, and problem/conventional behaviors). The results are presented in Table 4.

The first two columns of Table 4 present the standardized beta weights for belonging to either the occasional or regular smoking groups versus the nonsmoking group for females and males, respectively. The first model was not significant for males indicating that environmental factors played no role in differentiating smokers from nonsmokers for males. Two variables from the second model were significant for males. Higher disinhibition and greater alcohol or drug use in early adolescence were associated with a higher probability of membership in one of the smoking trajectories compared with the nonsmoking trajectory. For females, lower SES, having friends who smoked, higher disinhibition, lower school achievement, and more frequent use of alcohol or drugs were significantly related to a higher probability of membership in one of the smoking trajectory groups.

The next two columns of Table 4 present the standardized beta weights for belonging to the regular smoker group versus the nonsmoking and occasional smoking groups for females and males, respectively. The first model for males was not significant. However, within the second model, higher disinhibition and lower school grades were associated with heavy smoking. For females, lower parental SES, having a parent who smoked, and lower grades significantly increased the probability of being a heavy smoker.

The final two columns of Table 4 present the standardized beta weights for belonging to the regular smoker group versus the occasional group for females and males, respectively. Neither of the models was significant for either males or females. The lack of significance could have resulted from the relatively small number of subjects included in the analyses (occasional smoker group: $N = 21$ for males and $N = 50$ for females; regular smoker group: $N = 79$ for males and $N = 76$ for females).

4. Conclusion

Three distinct developmental trajectories of smoking were identified — non/experimental smokers, occasional/maturing out smokers, and heavy/regular smokers. Three trajectory groups were also identified by White et al., 2001 in another cohort from age 15–28 in a study of family environment and smoking. Sex differences in developmental trajectories and in smoking behavior were notable in the present study. The occasional/maturing out group was made up of more fe-

Table 3
Predictors of smoking trajectories in the total sample (standardized beta weight presented)

	Probability of smoking	Probability of heavy smoking	Probability of heavy smoking among smokers
Sex (0 = female)	−0.20*	−0.04	0.22
SES	−0.10	−0.11	−0.08
Pregnancy smoking	−0.10	−0.03	0.08
Parent smoking	0.07	0.10	0.09
Sibling smoking	0.05	0.09	0.14
Friend smoking	0.06	0.01	−0.05
Peer smoking	0.02	0.05	0.06
Self-esteem	0.04	−0.01	−0.06
Self derogation	0.02	−0.01	−0.02
Depression	−0.06	−0.01	0.05
Disinhibition	0.28*	0.18**	−0.04
Cigarette attitudes	−0.04	−0.01	−0.01
School attachment	0.03	0.08	0.14
Grades (1 = A, 8 = F)	0.14**	0.17**	0.12
Drug use	0.12*	0.05	−0.06
Delinquency	0.04	0.06	0.05
R^2	0.20***	0.14*	0.12
Adjusted R^2	0.16*	0.09*	0.04

* $P < 0.001$.
** $P < 0.01$.
*** $P < 0.05$.

Table 4
Sex differences in the predictors of trajectory group membership (standardized beta weight presented)

	Probability of smoking		Probability of heavy smoking		Probability of heavy smoking among smokers	
	Females	Males	Females	Males	Females	Males
Model I						
SES	−0.16*	−0.01	−0.21***	−0.04	−0.18	−0.03
Pregnancy smoking	−0.05	−0.11	0.03	−0.05	0.11	0.08
Parent smoking	0.12	0.08	0.15*	0.09	0.14	0.05
Sibling smoking	0.13	0.05	0.11	0.10	0.09	0.16
Friend smoking	0.21*	0.14	0.13	0.07	0.01	−0.11
Peer smoking	−0.07	0.10	−0.03	0.11	<0.01	0.10
R^2	0.13***	0.06	0.14***	0.05	0.10	0.04
Adjusted R^2	0.10***	0.03	0.11***	0.02	0.05	−0.03
Model II						
Self-esteem	−0.10	0.08	−0.09	<0.01	−0.02	−0.10
Self derogation	0.02	<−0.01	<0.01	−0.02	0.03	−0.03
Depression	−0.12	−0.03	−0.02	0.01	0.06	0.11
Disinhibition	0.20**	0.34***	0.13	0.26**	0.01	−0.02
Cigarette attitudes	−0.04	−0.09	−0.02	−0.02	≤0.01	0.06
School attachment	0.05	−0.01	0.05	0.11	0.05	0.30
Grades (1 = A, 8 = F)	0.29***	0.09	0.29***	0.19*	0.16	0.26
Drug use	0.16*	0.17*	0.08	0.06	−0.02	−0.18
Delinquency	<0.01	0.07	0.05	0.02	0.07	−0.03
R^2	0.20***	0.19***	0.13**	0.11*	0.04	0.12
Adjusted R^2	0.16***	0.14***	0.08**	0.06*	−0.04	0.02

* $P<0.05$.
** $P<0.01$.
*** $P<0.001$.

males than males. This trajectory reflects a maturing out in the late 20s, which may occur more often for women than men as women begin to have children and cut down or stop smoking (Labouvie, 1996). In contrast, females were more likely to start regular smoking earlier than males and being female significantly differentiated smokers from the nonsmokers. Thus, gender differences in transitions through smoking stages need to be addressed in future research (Mermelstein, 1999; Mermelstein and Borrelli, 1995).

Whereas most studies have defined smoking behaviors subjectively and used only one or two time points to determine categories of smokers, this study identified smoking groups based on developmental trajectories of smoking at five time points over an 18-year period. The findings are consistent with some of those from the earlier research. Specifically, smoking initiation and heavy smoking were most strongly related to lower educational achievement, higher disinhibition, and other drug use.

Higher levels of smoking and dependence and lower levels of cessation have been associated with lower educational achievement or commitment across studies (Chassin et al., 1996; Newcomb et al., 1989; Bailey et al., 1993; Diem et al., 1994). In addition, for females lower parental educational attainment (i.e. SES in this study) was associated with both smoking and heavy smoking. Other studies have also found a link between smoking and SES (e.g. Conrad et al., 1992; Rose et al., 1996a). There are several plausible explanations for the strong association between educational accomplishments and cigarette smoking. First, individuals with higher versus lower educational attainment may be more concerned about the health risks of smoking because of greater knowledge about them or greater stakes in society (Rose et al., 1996a). Alternatively, it may be that individuals with lower achievement levels may have neuropsychological difficulties, such as a short attention span or an inability to focus, which make them more susceptible to the physiological reinforcement of smoking (Milberger et al., 1997). Obviously, more research is needed to understand this association. However, regardless of the explanations, it is clear that smoking prevention programs are needed in lower income communities and should especially target students who do poorly in school.

The findings regarding disinhibition support earlier studies of cigarette smoking (e.g. Zuckerman, 1991). In fact, disinhibition has consistently been related to experimentation with all types of drugs (Bates et al., 1986). Individuals with high sensation seeking needs may begin smoking, as well as using other drugs, as a means to experience novelty and stimulation. As well, higher sensation seeking has been linked to other risk

taking behaviors, such as driving while intoxicated and engaging in unprotected sexual behavior (White and Johnson, 1988; Johnson and White, 1989). Thus, individuals who are higher in disinhibition may not be concerned about the risks of cigarette smoking as much as individuals who are lower. Cigarette prevention programs aimed at displacement or substitution of sensation seeking needs may be most appropriate for individuals high in disinhibition.

The association of cigarette smoking with alcohol and other drug use has been well documented in the literature (Kozlowski et al., 1993; Lewinsohn et al., 2000; Mayhew et al., 2000; Sher et al., 1996; Shiffman and Balabanis, 1996). The findings here support this literature and indicate that early use of alcohol or other drugs is related to the development of persistent smoking trajectories over time. (Note that in most cases the early use reflects alcohol rather than other drug use.) Given the consistency in findings supporting an association between cigarette use and other drug use, it may be beneficial to take a generic rather than a substance specific approach to preventive interventions (e.g. Pentz, 1998). Results of a number of large scale prevention trials research projects have demonstrated the efficacy of generic approaches in delaying the onset of use of a wide variety of substances including tobacco, alcohol, and marijuana (Pentz et al., 1989). The longer term impact of such approaches on persistent use should be evaluated.

In contrast to other studies of smoking (e.g. Chassin et al., 1986; Bailey et al., 1993; Bauman et al., 1990; Mayhew et al., 2000), the results did not provide strong support for an association between differential association variables and smoking in general or regular smoking in particular. In the total sample, none of the differential association variables were significantly related to trajectory group membership, and for males none of the differential association models were significant. For females, however, having friends who smoked differentiated smokers from nonsmokers and having parents who smoked differentiated regular smokers from those who never smoked or smoked only occasionally. Other studies have also reported an interaction between being a female and belonging to a smoking network or having a parent, who smoked as being predictive of transitions in smoking behavior (Mayhew et al., 2000). In addition, Kandel and Wu (1995) found that females were more affected than males by mothers' smoking. Research on drug use other than nicotine has also found that females are more susceptible to peer influences (White and Huselid, 1997). Thus, females compared with males appear to be more susceptible to differential associations when it comes to cigarette smoking and other types of drug use.

Contrary to the hypotheses, intrapersonal characteristics (other than disinhibition) that would derive reinforcement value from smoking were not related to trajectory group membership. It was especially surprising not to find a significant relationship between regular smoking and depression, which has been found in both clinical and epidemiological studies (Breslau et al., 1993). The use of the SCL-90R (Derogatis, 1977), which measures transient states (i.e. feelings 'in the last month'), may have accounted for the failure to find a significant effect. Perhaps, if more enduring patterns of depression had been assessed, the findings may have differed. Also, studies that have reported strong links between depression and cigarette smoking have used more stringent diagnostic measures of nicotine dependence, as well as depression (e.g. Breslau et al., 1993). There have been some other studies, however, which also failed to find an association between depression and smoking (Patton et al., 1996).

None of the variables examined could differentiate occasional from regular smokers among those who smoked in the total sample or among males or females. One explanation why these two groups of smokers could not be differentiated may be that the risk factors were measured in early adolescence prior to the development of smoking behaviors for most participants. Most individuals in the occasional trajectory group stopped smoking by T5, and this group actually represents an adolescence-limited smoking group. Thus, it is possible that other factors, such as smoking experiences and consequences, as well as life course changes, may affect developmental trajectories and be better able to predict maturation out between adolescence and adulthood (Laub and Sampson, 1993). For example, Chen et al., 2001 found that those individuals who became married to nonsmokers and who experienced a reduction in the number of friends who smoked were more likely to stop smoking in young adulthood. Their results suggested that changes in social networks are especially important for maturation out of cigarette smoking. Another explanation might be that given the small number of individuals in these analyses (especially, males in the occasional/maturing out group), power to find significant differences may have been limited.

There are other differences between this study and other studies that might account for why we did not replicate the importance of some interpersonal and intrapersonal predictors of the various stages of cigarette smoking (for a review see Mayhew et al., 2000). First, this study used growth mixture modeling to develop homogeneous groups of individuals characterized by their individual developmental trajectories of smoking behavior over time. The groups that emerged differ from conceptually-defined stages based on the number of cigarettes smoked or frequency of smoking at a given point in time, that have typically been used in prior studies (Mayhew et al., 2000). For example, the

nonsmoker group included some individuals who had experimented with cigarettes. Likewise, the regular smoker group included individuals with varied levels of smoking at each measurement occasion. In addition, we followed participants over an 18-year period from early adolescence into young adulthood. Many of the other studies that examined predictors of stages of smoking confined their period of observation to the adolescent years. Therefore, although rare (Colby et al., 2000; Giovino, 1999), these studies may have missed some late onset smokers. As well, earlier studies may have excluded those subjects who stopped smoking during the transition from adolescence into young adulthood.

Besides the limitations described above, there are other limitations that should be considered when examining the findings of this study. First, the data set did not contain information on motivations for smoking and consequences of use. Therefore, the reinforcing and punishing effects of cigarettes, such as cravings and withdrawal, could not be assessed and these may be important in the transitional stages of smoking, especially for the process of becoming a regular smoker and eventually dependent (Shadel et al., 2000; Shiffman et al., 1994). Although we did include multiple domains in our analyses, we did not include individual psychopharmacological and genetic factors that might differentiate occasional from regular smokers. Research studies have demonstrated that underlying physiological responses and sensitivity to nicotine (Shadel et al., 2000; Silverstein et al., 1982), which may be genetically determined (Heath and Martin, 1993; Pomerleau, 1995; Seaton and Vesell, 1993), are important for the development of persistent smoking behavior. As well, we did not include broad sociocultural factors that might play a role in influencing transitions in cigarette use behaviors (Mayhew et al., 2000). There is obviously a need to better operationalize these areas in future research on cigarette use (Mayhew et al., 2000; Shadel et al., 2000).

Second, the measures of cigarette use and the risk factors were obtained from the subjects themselves without any type of validation (e.g. physiological measures or significant other reports). The use of a single reporter can create method bias and may account for a portion of the observed associations among variables. Further, the risk factors were measured after the onset of smoking for some subjects. Therefore, readers should refrain from making unwarranted causal assumptions. Finally, the sample was comprised primarily of white, middle and working class individuals. Thus, the findings may not be generalizable to lower class and nonwhite populations.

Overall, the findings suggest that there are several different developmental trajectories of cigarette smoking. Among those who start smoking, some individuals mature out and others become regular smokers. It is important, therefore, to examine transitions and turning points from adolescence to adulthood that affect cessation and escalation.

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